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The impacts of diabetes research from 31 European countries in 2002 to 2013

Abstract

The evaluation of a country's medical research outputs should include measures of their impact on medical practice, on health policy and decision-making, as well as conventional citations in the serial literature. This study examined three measures of impact: geometric mean, arithmetic mean and world scale mean, applied to one disease area, namely diabetes, to investigate the amount of agreement between them in terms of the impacts of the research of different European countries. Firstly, citations to diabetes research papers in the Web of Science from 31 European countries from 2002 to 2013 were analysed. Papers from Finland, Switzerland, Denmark and the UK were the most cited by other papers on both geometric and arithmetic means, and in terms of their presence in the top 5% of papers with the most citations. Secondly, the references on 103 European diabetes clinical practice guidelines from 21 countries were analysed. Papers from the Netherlands, Finland, the UK and Austria were the most cited in the clinical guidelines relative to the countries' presence amongst diabetes research. Finally, an analysis of newspaper stories about non-communicable disease research from 22 European countries included 822 on diabetes research (9.6% of the total) and showed that the subject was of substantial interest. The countries whose papers were the most cited relative to their presence in the subject area were Finland, Norway, the UK and Belgium; those from Japan, China and South Korea were not well cited. Different European countries scored highly on these three measures. Scandinavian countries and the UK appeared to perform strongly on all three, but Switzerland only on conventional citation counts. The increased emphasis placed on demonstration of the social and economic impacts stemming from research make the described methodologies herein of particular value to future evaluations of medical research.

Keywords: diabetes, citations, clinical practice guidelines, newspaper stories, research impact, research evaluation

Introduction

The evaluation of research can be performed at the individual level (*e.g*. as a guide to promotion or to the award of research grants (Lewison, Cottrell, and Dixon 1999)), institutional level (where universities vie to ascend the rankings in various league tables (Fowler 2014)), or national level (where it can show if a country's research policies are effective (Ding *et al.* 2013; Campbell *et al.* 2010)). It is, or should be, concerned both with scientific excellence and the practical implications of the research in the real world. The balance between these two criteria depends very much on the subject matter, but most medical research needs to be judged on both.

There is an extensive literature on the way to measure research excellence, and this is conventionally based on a combination of peer review and citation counts of papers by other research papers (Hirsch 2005; Moed 2007; Neylon and Wu 2009; Insights 2013). To some extent these are related, because papers submitted to journals are subjected to peer review and the higher the prestige of the journal, the stricter the peer review (and the higher the rejection rate). This in turn tends to help papers in leading journals to gather citations from other authors, and although many papers achieve citation scores well above or below the average for their journal, by definition, the average of their scores will reflect the journal impact factors calculated on a diachronous basis.

The difficulty is that citation counts are not normally distributed, and so their arithmetic mean is not regarded as a valid indicator of the impact of one group of papers compared with another (Bornmann *et al.* 2008; Weale, Bailey, and Lear 2004; Gargouri *et al.* 2010; Nieminen *et al.* 2006). It has recently been suggested that their geometric mean is a better measure (Bornmann *et al.* 2008; Weale, Bailey, and Lear 2004; Gargouri *et al.* 2010; Nieminen *et al.* 2006), although this has to be calculated by the addition of unity to each score, and then deducted from the (enhanced) mean value.

Alternatively, the numbers of papers from a group that receive enough citations to put them in the top centiles of the field have been viewed as a better criterion as some authors consider that only these papers are really important (Waltman and Schreiber 2013). The method of calculation of the appropriate indicators was discussed by Bornmann (2013). However, several authors have examined the papers in the top centiles of their field without taking account of the time window for citations (for example, Aminian et al, 2014; Li & Jiang, 2016; Kim *et al.*, 2017). This clearly will disadvantage countries (and institutions) whose output has expanded rapidly as their papers will have had less time to garner citations. It is essential to use a fixed citation window for this and other analyses of citation counts.

All three indicators have merit, so that if a country or institution scores highly on all three, its research can be considered as meritorious. However, there is an important caveat: all the citation scores should be based on fractional counts of how much a country contributed to a paper, not integer counts of the number of papers they contributed to, as otherwise small countries, most of whose output is multi-national, will benefit disproportionately from the high citation counts that such papers often attract (Rodríguez-Navarro 2012; Waltman and van Eck 2015). For example, in our study we found that Danish diabetes papers had a mean five-year citation count in the Web of Science (WoS, © Clarivate Analytics) of 27.8 cites on an integer count basis, but only 20.6 cites on a fractional count basis. Consequently, all the citation count data presented in this paper are based on fractional address counts.

Research influence can also be assessed by the extent to which a paper is cited internationally. Research papers tend to be more frequently cited by their authors' fellow citizens than would be expected from their countries' presence in the literature of the given subject (Smith *et al.* 2014). The "Over-Citation Ratio" (OCR) is greater for countries with a small output of research papers but it is decreasing with time as communication becomes easier.

However, it is arguable that indicators based on the "real world" provide a better measure of research merit or utility. In this study, in addition to traditional research impact metrics, we investigated from an international perspective the references on clinical practice guidelines (CPGs), and the papers written about in newspaper stories of progress and advances in biomedical science related to a specific condition, here, diabetes. There is already evidence that papers informing medical practice also achieve high citation scores (Thelwall & Maflahi, 2016; Thelwall *et al.*, 2017).

CPGs are increasingly being produced by national government agencies, regional governments (*e.g.*, in Scotland, the provinces of Spain and counties of Sweden), and international specialist societies. In diabetes, the number of produced clinical guidelines in Europe rose from hardly any at the beginning of this century to about 15 per year recently. They are increasingly being used to guide clinical practice (Payne *et al.* 2013; Corwin *et al.* 2014), but with variable actual impact (Polk *et al.* 2016). There have been a number of studies (Grant *et al.* 2000; Kryl *et al.* 2012) on the references that they cite as evidence, but all have covered just one country except for that of Andersen (2013). However, because the papers cited by CPGs are relatively clinical, rather than basic, these citations can only be used for the evaluation of clinical work. They do, however, redress the balance somewhat because basic research tends to be better cited than clinical work in the academic literature (Gee & Narin, 1986; Lewison & Devey, 1999; van Eck *et al.*, 2013).

Medical research affects the public more than research in almost all other fields, and in Western Europe, it receives significant support from the non-profit sector, particularly charities (Dawson *et al.* 1998). Citizens are expected actively to take some care of their own health, and when they become ill, are encouraged to act as educated consumers rather than as passive patients. They can obtain information from a variety of sources, including newspapers, whose stories (unlike those on social media websites) are relatively permanent and can be analysed by bibliometricians. Despite declining circulations, newspapers can still be very influential with politicians, their advisers, healthcare professionals, researchers and the general public. Indeed, stories in newspapers (Phillips *et al.* 1991) and from broadcasters (Lewison and Sullivan 2008) have been shown to lead to more citations in the literature. There have been many studies of mass media reports of medical research (Hanson *et al.* 2017; Lai and Lane 2009; Akamatsu, Naito, and

Nakayama 2009; Bartlett, Sterne, and Egger 2002); very few have been able to cover newspapers in multiple countries (Lewison 2008; Pallari *et al.* 2017; Casino *et al.* 2017).

Both these indicators involve work with many different European languages, which was made possible within the EU-funded project (MAPPING NCD) on the mapping of research outputs across five chronic non-communicable diseases and their impact. In this paper, the focus is on countries as units of assessment, rather than research institutions. This way the different entities should have enough published papers for comparisons to be made on the basis of both clinical guideline and newspaper citations, which are inevitably far fewer than those in the serial academic literature. However, we have also considered the citations to different subject areas within diabetes research because these can affect the apparent performance of individual countries, which may concentrate their research efforts on different areas. For example, Italy carried out relatively more research on the effects of diabetes on the liver than Germany, but the reverse was true for research on the effects on feet (Begum *et al.*, 2017; Table 1). As we shall see, research on the effects on the liver is much better cited than research on the effects on feet (Table 4), and this is part of the reason why Italy's citation performance overall is superior to that of Germany (Table 3).

Methodology

Sample

With the help of our European partners and King's College London graduate students with relevant language skills, we collected outputs of diabetes research in the WoS from 31 European countries (EUR31): the 28 Member States of the European Union plus Iceland, Norway and Switzerland. A list of these countries, and some others, with their ISO2 codes is given in Table 1. In addition, we searched many European newspapers for stories about non-communicable disease research, including diabetes, and compiled a database of their parameters, and of the WoS papers that they cited. Finally, we compared the OCR for references on CPGs and for papers cited in newspaper stories, with those found for journal papers, to see if these two types of documents were more or less nationalistic in their choice of research literature.

Table 1. List of countries with their International Standards Organization digraph (ISO2) codes.

ISO2	*Country*		*ISO2*	*Country*		*ISO2*	*Country*
AT	Austria		FR	France		NL	Netherlands
AU	Australia		GR	Greece		NO	Norway
BE	Belgium		HR	Croatia		PL	Poland
BG	Bulgaria		HU	Hungary		PT	Portugal
BR	Brazil		IE	Ireland		RO	Romania
CA	Canada		IL	Israel		SE	Sweden
CH	Switzerland		IN	India		SG	Singapore
CN	China (P.R.)		IS	Iceland		SI	Slovenia
CY	Cyprus		IT	Italy		SK	Slovakia
CZ	Czech Rep.		JP	Japan		TR	Turkey
DE	Germany		KR	Korea (South)		TW	Taiwan
DK	Denmark		LT	Lithuania		UK	United Kingdom
EE	Estonia		LU	Luxembourg		US	United States
ES	Spain		LV	Latvia			
FI	Finland		MT	Malta			

The database of diabetes papers was created by means of a special "filter" that was applied to the WoS, both the Science Citation Index-Expanded and the Social Sciences Citation Index, for 2002-13. This filter contained the names of 45 specialist journals (which accounted for 42% of the diabetes papers) and 35 selected title words and was developed in consultation with Diabetes UK and Bocconi University. It had a precision (p, specificity) of 0.90 and a recall (r, sensitivity) of 0.98, and a calibration factor of p/r=0.92. It identified 40,547 papers (articles and reviews) in the WoS for the 12-year period, which were downloaded as text files, and then converted to a MS Excel spreadsheet by means of a special VBA program written by Philip Roe of Evaluametrics Ltd.

Citations of papers in the serial literature

The diabetes papers from the years 2002-11 were divided up into several groups, each of fewer than 10,000 (which is the upper limit permitted for citation scores to be determined with the WoS), so that a citation analysis could be carried out. The WoS allows citation data to be downloaded, 500 papers at a time, as a series of Excel files, which can then be combined into a single file by means of another VBA program. This included the original paper titles and sources in exactly the same formats as those in the original file of papers. Citation counts were determined for the first five years, including the publication year; this is a compromise between the need for immediacy and enough time for the peak citation year to be included. This is referred to as Actual Citation Impact (ACI). The ACI values were transferred to the file of papers by means of a match on the paper titles. This was not possible for some papers, either because the title was too long (> 255 characters), or because it contained special characters like quotation marks or semi-colons. For these papers, a match was made on the source (journal, year, volume, issue, pages), or on part of the title not containing special characters, and the ACI values were then copied across. Although the WoS may contain more than one document with the same title, the others are usually correspondence following publication of the original paper, and these are not articles or reviews.

The papers' addresses were parsed to show the fractional counts of each European country's contribution, and these fractional counts were multiplied by the ACI value of each of the papers to give a fractional count of citations for each country. In addition, each ACI value was increased by unity, and then its logarithm to base 10 was calculated. These converted citation scores for each paper were also multiplied by each country's fractional contribution. The sums of the original and of the converted weighted citation counts for each EUR31 country were calculated, and then divided by the total fractional counts of the number of citable papers to give two mean values. Those of the converted citation counts were then used as the exponents of 10, and unity subtracted from the results, to give the geometric mean citation count, as compared with the arithmetic mean. (Typically, the geometric mean calculated in this way is about half as large as the arithmetic mean, see Tables 3 and 4.) Citation scores were only determined for the EUR31 countries, and not for the non-EU countries that may have co-authored the papers, as their outputs would have been incomplete in our file.

The percentages of a country's citable papers that received enough citations to put them in the top centiles of the group were easily determined on the basis of fractional counts after the file of papers was sorted by ACI score, descending. The over-citation ratio, OCR, was determined for the diabetes papers from the leading countries (with at least 1% of world output) in 2005 and 2010. For example, French diabetes papers in 2005, numbering 318 out of a world total of 6,733, or 4.8%, received 906 out of their 6,050 citations in 2005-09 from papers with a French author, or 15.0%. So, their OCR was 15/4.8=3.1. A plot of OCR against percentage presence for the leading countries showed that it could be represented by means of a power law, and this equation gave OCR values that could be compared with those observed for citations from the CPGs and newspaper stories.

Impacts on clinical practice guidelines and newspaper stories

We found 103 diabetes CPGs from 21 European countries. The sets of references were tabulated into Excel spreadsheets, and then converted into WoS search statements so that the cited papers could be identified, and their details downloaded. For some CPGs, it was possible to semi-automate this process by means of a macro (written by Philip Roe of Evaluametrics Ltd) which identified the different components of a reference by the presence of full stops after the list of authors and the title, and the year as a number between 1960 and 2015. It then generated search statements that contained the three longest words of the title, the publication year and the name of up to three authors. However, some references were not journal papers, or were in journals not covered by the WoS, and very few were even incorrect.

We examined what types of diabetes research were involved in the papers cited by the guidelines, using the same sub-filters as had been developed for analysis of the European diabetes research papers. We also determined which countries' research had been most cited by the CPGs from *other* countries, compared with their presence in diabetes research as recorded in the WoS. This correction was made in order to compensate for bias because some countries published more CPGs, and their references, than others.

The recording of European newspaper stories on biomedical research involved the development of a series of protocols, the involvement of a multi-lingual team who underwent training in a series of sessions held by EP at KCL and were closely monitored to ensure that all were working with the same methodology (Pallari & Lewison, 2017). Diabetes-related search terms were developed in English, and then translated into 16 other languages and used to search the archives of the selected European newspapers. The English diabetes-related search terms were:

diabet + (research* OR study OR scientists OR expert*).*

However, these generated many false positives, and each story identified by these search terms had to be read and retained for inclusion only if it was relevant, *i.e.*, it cited an identifiable journal paper. The members of the multi-lingual team then extracted salient data from each story into a standardised Excel spreadsheet, including translations into English of the headline and a short synopsis. The data included codes to connote the NCD and subject areas within it, details of the cited paper and also of any commentators on the significance of the results. The researchers then searched the WoS for the cited papers, one at a time, and downloaded their bibliographic data to numbered files so that they could be matched to the newspaper stories in the main spreadsheet. Finally, all the individual contributions were put together to create one multi-national file of both stories and cited papers that could be analysed.

The stories were coded by the researchers to show which research domain was being described, and also what type of diabetes or its *sequelae*, see Table 2. The cited papers were analysed by a

VBA program to reveal their research level (from RL=1.0 for clinical observation to RL=4.0 for basic research, (Lewison and Paraje 2004)) based on their individual titles and the journals in which they were published. They were also analysed by another VBA program to show the fractional presence of each country among their addresses. All these parameters could then be compared with the *corpus* of European diabetes research papers in 2002-13 (Begum *et al.* 2017) to show whether the journalists had made an unbiased selection from them, and in particular whether they had over- or under-cited the research from their compatriots. Although the papers cited by CPGs went back many years before the start date of 2002 for our study, this was much less the case for newspaper stories as they tended to report new research results, and only seven of the 822 cited papers appeared before 2002.

Table 2. List of diabetes research subject areas, with codes used for the tables and figures.

Code	*Subject area*		*Code*	*Complications*
TY1	Type 1 diabetes		FEE	Feet
TY2	Type 2 diabetes		CAR	Cardiovascular
GES	Gestational diabetes		KID	Nephropathy
NEO	Neonatal diabetes		NEU	Neuropathy
MOD	Maturity Onset Diabetes of the Young (MODY)		LIV	Liver
ADA	Latent Autoimmune Diabetes of Adults (LADA)		HYP	Hypoglycaemia
GEN	Genetics		PSY	Psychosocial
			RET	Retinopathy

Results

Citations to diabetes research papers

European diabetes research papers are somewhat more highly cited than the world average (arithmetical basis) since 2004, mainly because the latter is increasingly affected by Chinese papers, and others from East Asia, which tend not to be well cited. In 2009, for example, the mean five-year counts were 17.9 cites for the EUR31 papers, 15.9 cites for the world but only 14.7 cites for non-European papers. Table 3 shows the citation performance of all 31 European countries in 2002-11.

Table 3. Citation performance of EUR31 in diabetes research in 2002-11, fractional counts, ranked by % with 58 or more cites (WorldScale, W.S.), and with five-year citation scores based on arithmetic and geometric means. ***Values of the worldscale, arithmetic (Arith) and geometric (Geom) means > twice the European means shaded deep green; if > 1.41 x means shaded light green; if < 0.71 x means, shaded yellow; if < 0.5 x means, shaded pink. For country codes, see Table 1.***

Country	*Citable*	*Arith*	*Geom*	*W.S.*		*Country*	*Citable*	*Arith*	*Geom*	*W.S.*
FI	984	21.6	11.5	145		ES	1798	12.3	6.4	48
CH	641	19.7	10.0	139		CZ	262	10.1	5.4	45
BE	590	19.9	9.1	117		LV	17	11.3	5.7	42
IS	29	35.2	9.1	115		HU	248	10.5	5.5	36
UK	5376	19.7	9.8	111		EE	30	11.4	7.2	34
DK	1611	20.6	10.7	110		PT	171	12.4	7.3	32
NL	1718	18.2	10.6	101		RO	120	6.8	2.8	17
FR	2517	15.4	6.8	93		LU	7	11.6	6.4	16
AT	567	14.3	6.7	90		BG	55	6.8	3.2	15
IT	3328	16.2	8.8	83		GR	616	10.8	6.5	15
SE	1778	17.7	9.9	78		PL	760	7.6	4.3	14
DE	4125	13.2	5.8	71		LT	23	5.5	2.0	13
CY	4	6.9	4.1	71		SK	154	7.1	4.0	9
NO	371	16.2	9.9	62		HR	134	5.6	3.1	4
IE	203	13.8	7.0	58		MT	15	3.8	2.5	0
SI	89	7.9	3.8	55						

The three citation measures are fairly well correlated (r^2=0.7), but the rankings are not quite the same. Finland (FI) leads in the number of papers in the top 5% and in the geometric mean of all its papers, although Iceland (IS), with fewer than 30 papers, has a much higher arithmetic mean. It is noticeable that the 13 new "accession Member States" in eastern and southern Europe all score less than 0.71 times the mean on either one or both averages, and six of them less than half the mean on both averages.

We found that, of the 31,906 citable papers (see Table 4), the top 5% (1,595 papers) each received 58 cites or more; in fact, there were 1,642 papers with this ACI value or greater, that is

5.15%. For example, there were 66 such papers with an Austrian address, with a fractional count of 26.4 papers. This represented 4.66% of the total (567.0) Austrian fractional count of citable papers, so on this criterion Austria scored slightly less than par, or 100x4.66/5.15=90.4 on the "WorldScale" system (Lewison *et al*. 2007), where the mean performance is given a score of 100. The 15 subject areas provided on Table 4 also score differently on citation counts.

Table 4. Citation scores for 15 subject areas in European diabetes research in 2002-11, integer counts, ranked by percentage with 58 or more cites (top 5%), and with five-year citation scores based on arithmetic and geometric means. ***Subject percentages in top 5% and values of the arithmetic (Arith) and geometric (Geom) means > 1.41 times the European mean shaded green; if < 0.71 x means, shaded yellow; if < 0.5 x means, shaded pink. For codes for subject areas see Table 2.***

	Citable	*5%*	*WS*	*Arith*	*Geom*		*Citable*	*5%*	*WS*	*Arith*	*Geom*
LIV	866	78	175	22.9	13.1	TY1	4603	172	73	14.9	7.8
TY2	10390	801	150	23.1	11.2	NEU	802	28	68	14.3	8.3
NEO	183	14	149	21.4	11.4	HYP	91	3	64	11.4	5.8
GEN	4076	236	112	20.5	10.5	RET	1081	24	43	12.4	6.6
CAR	4046	226	108	19.0	9.2	MOD	144	3	40	16.3	10.9
Total	**31906**	**1642**	**100**	**17.6**	**8.5**	GES	617	12	38	11.3	6.0
KID	1950	89	89	16.2	8.1	FEE	672	10	29	11.0	6.3
PSY	371	14	73	14.1	7.8	ADA	66	0	0	10.3	6.8

There is less variation between subject areas than between countries, but research papers on the effects of diabetes on the liver, type 2 and neonatal diabetes are clearly the most cited, and those on latent autoimmune diabetes of adults, the effects on feet and gestational diabetes are the least cited. This should be borne in mind if efforts are made within a country to re-balance its diabetes research portfolio.

International citations to European diabetes research papers

We obtained OCR values for the 22 leading countries in diabetes research in 2005 and 2010. However, those whose presence was < 1% of the total were not analysed. This left 17 countries for both years of which 11 were European. Figure 1 shows the OCR values in 2010 for these countries plotted against their percentage presence in world diabetes research in that year, on log-log scales.

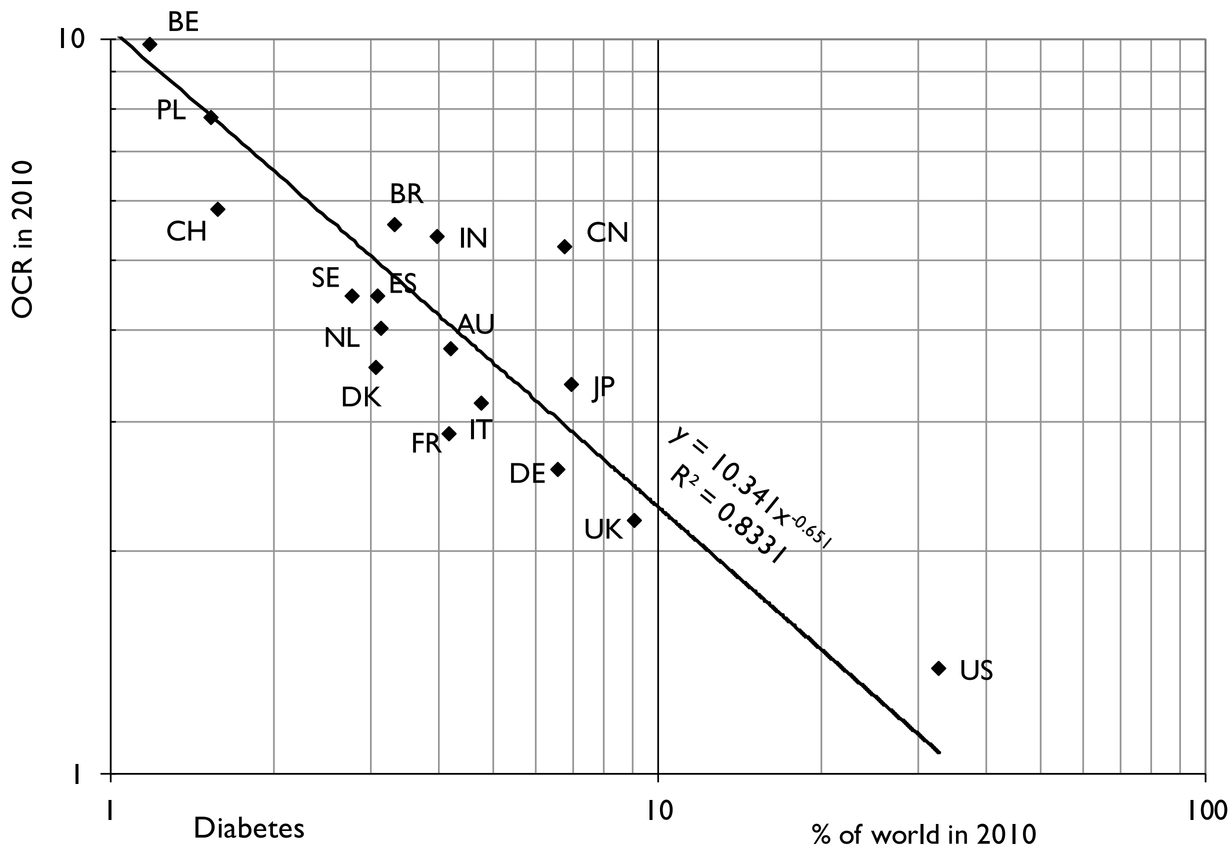

Figure 1. Plot of 17 countries' Over-Citation Ratio for diabetes research papers against their presence in diabetes research in 2010, integer counts. ***For country codes, see Table 1.***

This figure suggests that most of the countries whose points appear below the line and are over-citing their own research less than the amount expected are European, but that there are big differences between them. Table 5 shows the expected and observed OCRs for the 17 countries for which we have reliable data.

Table 5. Citations to diabetes research papers in 2010 from 17 countries with > 1% of world (wld) outputs, integer counts, over-citation ratio (OCR) observed and expected based on least-squares correlation line OCR=10.34*p$^{-0.651}$, ranked by ratio of observed (obs) to expected (exp) OCR. *See Table 1 for country ISO codes.*

ISO	*Papers*	*% wld*	*Cites*	*Own*	*Own, %*	*OCR, obs*	*OCR, exp*	*OCR ratio*
FR	418	4.2	8700	1055	12.1	2.90	4.08	0.71
DK	307	3.1	7573	830	11.0	3.57	4.98	0.72
CH	158	1.6	4100	379	9.2	5.85	7.68	0.76
NL	312	3.1	8505	1068	12.6	4.03	4.93	0.82
SE	278	2.8	7026	870	12.4	4.46	5.32	0.84
DE	657	6.6	11226	1908	17.0	2.59	3.04	0.85
IT	477	4.8	11473	1747	15.2	3.19	3.74	0.85
ES	308	3.1	6111	840	13.7	4.46	4.97	0.90
UK	908	9.1	18540	3722	20.1	2.21	2.46	0.90
AU	419	4.2	9768	1546	15.8	3.78	4.07	0.93
PL	153	1.5	1745	208	11.9	7.79	7.84	0.99
BE	118	1.2	2844	330	11.6	9.84	9.29	1.06
JP	698	7.0	9205	2168	23.6	3.38	2.92	1.16
BR	332	3.3	3790	703	18.5	5.59	4.74	1.18
IN	396	4.0	4212	896	21.3	5.37	4.22	1.27
US	3268	32.7	51299	23284	45.4	1.39	1.07	1.30
CN	676	6.8	8853	3112	35.2	5.20	2.98	1.74

According to this criterion, the papers with the least country OCR, compared with that expected from their presence in world diabetes research in 2010, were those from France (FR), Denmark (DK), Switzerland (CH) and the Netherlands (NL).

Diabetes clinical practice guidelines and their evidence-base

There has been a big increase in the number of CPGs on diabetes in the last few years. The 103 CPGs that we analysed had a total evidence base of 5,941 references, of which the earliest was from 1961 and the latest from 2014. Figure 2 shows the percentages of European diabetes research papers (abscissa), and the corresponding percentage of these references in each subject area on CPGs (ordinate). The relationship is not linear, but the correlation is high, indicating that the European diabetes research outputs appear to be appropriate to the evidence cited by CPGs, except that this has few papers on genetics (GEN), or liver *sequelae* (LIV). On the other hand, the CPG references included more than 7% on diabetic feet (FEE), whereas these accounted for barely 2% of European diabetes research.

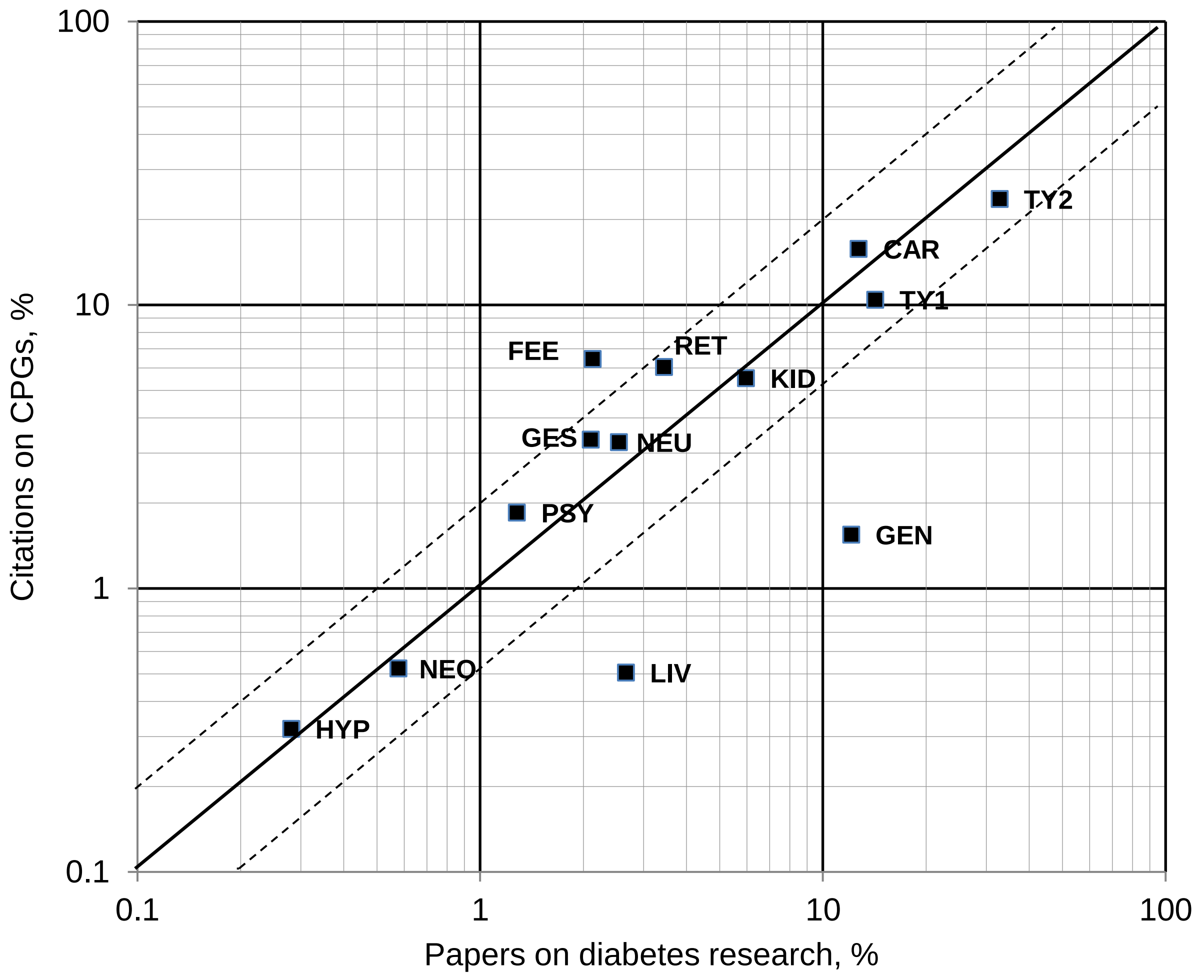

Figure 2. **Relationship between European diabetes research subjects and evidence base of 103 European clinical practice guidelines.** ***See Table 2 for subject codes. Dashed lines show values twice and half those of equivalence.***

The countries whose research is cited by these CPGs are for the most part European ones, see Figure 3. The countries whose research is most cited are the Netherlands (NL), Finland (FI) and the UK, followed by Austria (AT), Denmark (DK), Switzerland (CH) and Belgium (BE). These countries are all publishing papers that are well-cited academically, but not in the same ranking order. French research is slightly under-cited by CPGs despite having a fair citation performance in Table 3.

However, these ratios of observed to expected numbers of references are inevitably biased because of the varying numbers of references from CPGs from different countries. A fairer basis for comparison is to distinguish between references to a country's papers from its own CPGs, and those from CPGs from other European countries. This is shown in Figure 4 for those eight European countries with at least 100 references from the 103 diabetes CPGs.

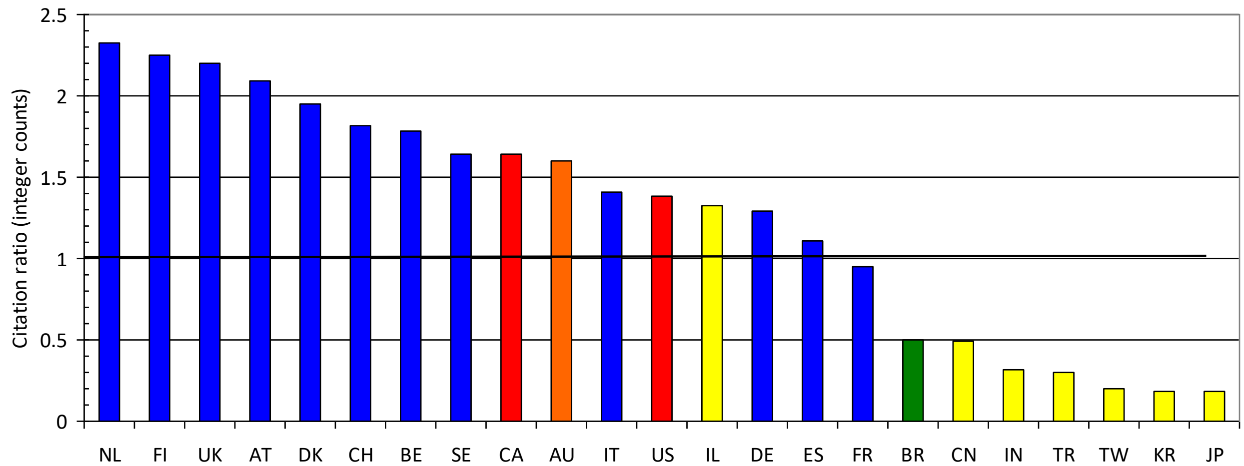

Figure 3. Over- (or under-) citation ratio for countries' papers on European diabetes CPGs compared with their presence in diabetes research, 2002-13, integer counts. *European countries blue, north American countries red, east Asian countries yellow; south American country green, Australia orange. See Table 1 for country ISO codes.*

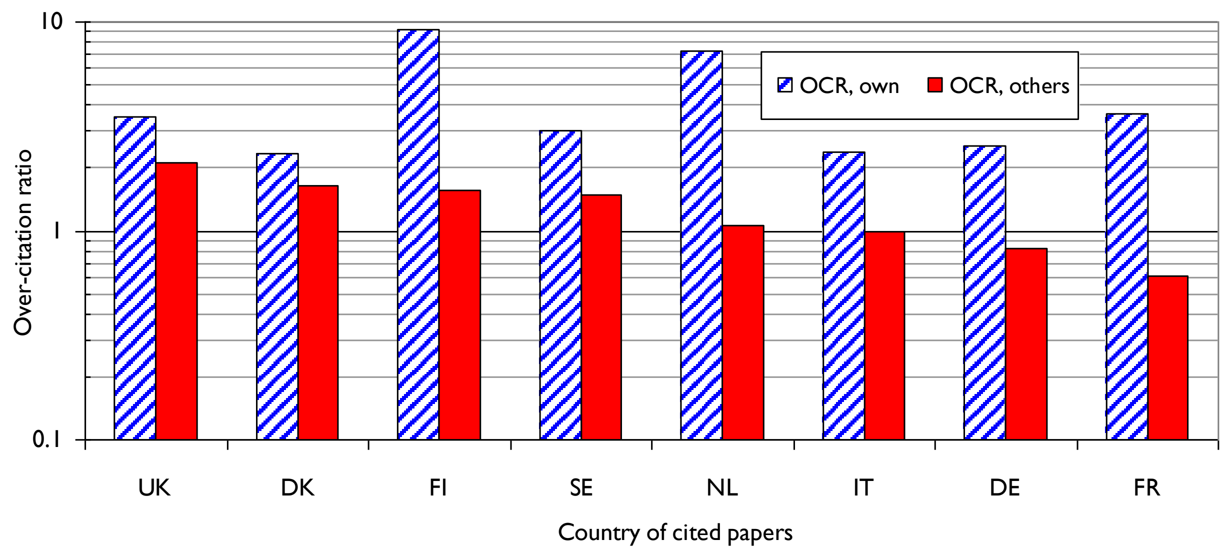

Figure 4. Over-citation ratio for eight European countries' papers cited by diabetes CPGs by own country (blue striped columns) and from CPGs from other European countries (red columns) compared with their presence in diabetes research, 2002-13, fractional counts. *See Table 1 for country ISO codes.*

The references on CPGs were very clinical, as expected (Lewison and Devey 1999; Rajendram, Lewison, and Preedy 2006; Lewison and Sullivan 2008), and the papers were more clinical than the average for the journals in which they were published. On a scale from 1.0=clinical observation to 4.0=basic research, the titles of individual guideline reference papers gave an RL (papers) of 1.09 compared with 1.68 for EUR31 diabetes research; the corresponding figures for the research levels of the journals were 1.44 compared with 1.91. By way of illustration, the journals whose research levels in recent years correspond to these values are: 1.09 - *BMJ*; 1.44 -

Diabetes Research & Clinical Practice; 1.68 - *Nephrology Dialysis Transplantation;* 1.91 - *Journal of Hypertension*.

Although the earliest paper cited by these CPGs dated from 1961, most were fairly recent, with the median year being 2005 and the inter-quartile range being from 2000 to 2008. Figure 5 shows that the peak gap between publication of a paper and its citation on a CPG is about two years, and just over half the cited references are five years old or more recent. This can be compared with the corresponding curves for the temporal distributions of citations to European diabetes papers published in 1985 (diachronous citations) and of references on 2013 papers (synchronous references). The two synchronous distributions are rather similar, with peaks in the second year before publication, but the CPG references are slightly more recent than the WoS ones. This shows that the process whereby recent research is taken into account in the development of recommendations for clinical practice is good. However, it is not up-to-date in all countries.

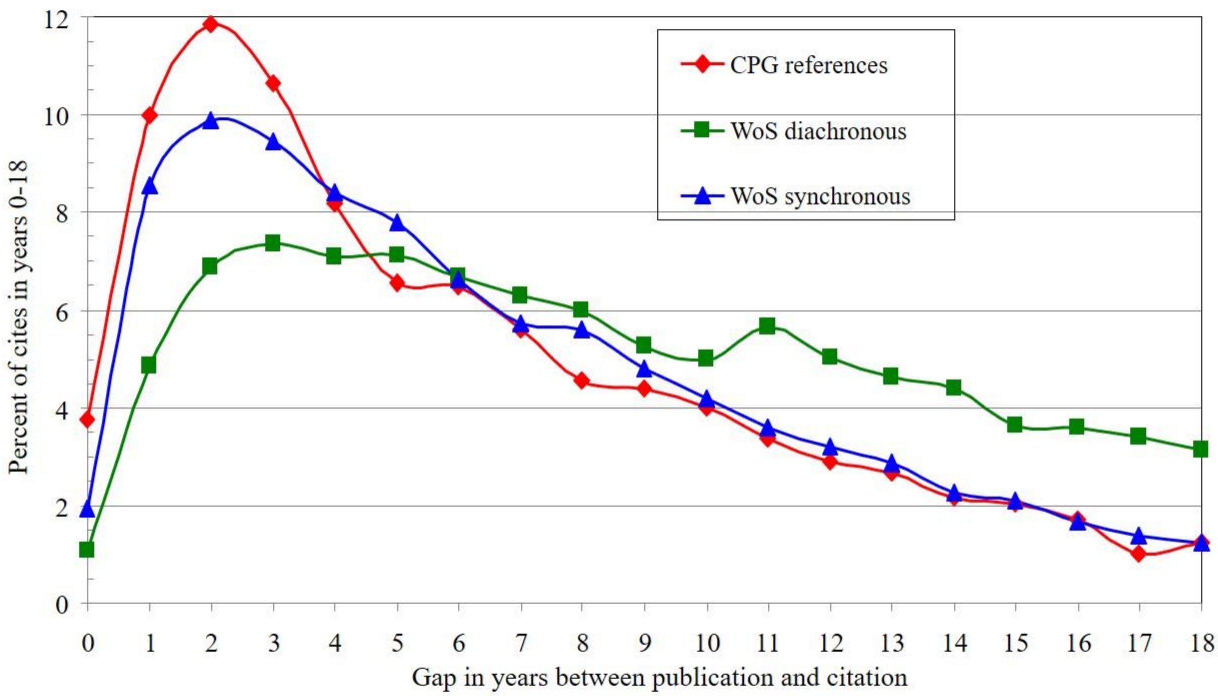

Figure 5. The gap between publication of a paper and its citation on a diabetes CPG (red), the gap between European diabetes publications in the WoS in 1985 and the years in which they were cited diachronously by other papers (green), and the years of the references on European diabetes publications in the WoS in 2013 (synchronous, blue).

There were rather large differences between countries in the immediacy of the evidence that was cited by their diabetes CPGs, as shown in Figure 6. The range was from 10 years for Finland (FI) to only three years for Croatia (HR). This last finding is perhaps surprising, as Croatia is not particularly research-active in diabetes, and none of the 81 references on its two CPGs had a Croatian author.

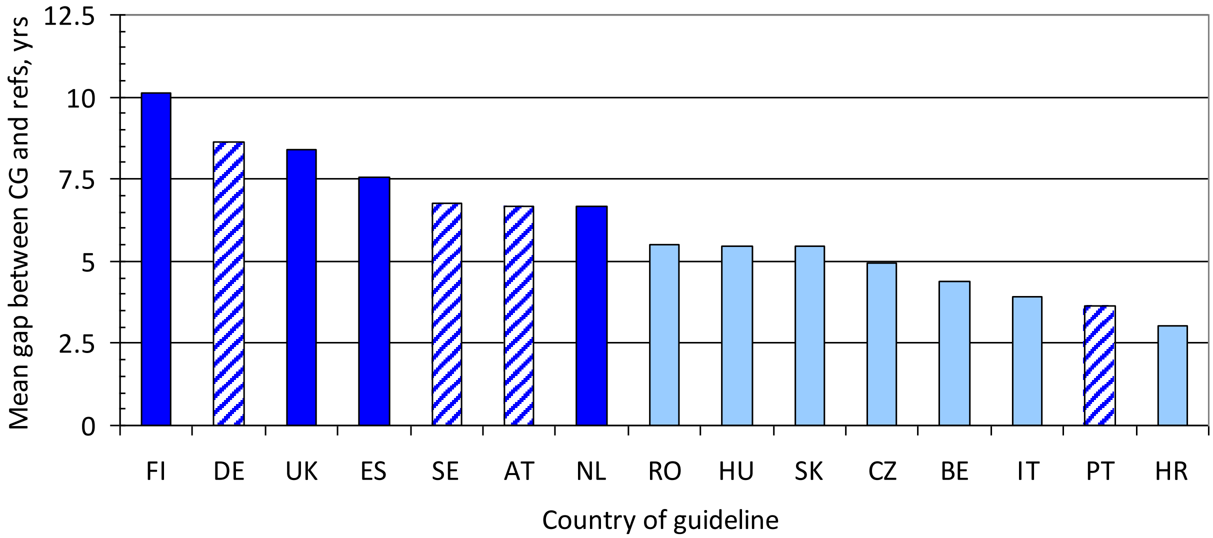

Figure 6. Mean gap between publication of a clinical practice guideline for diabetes and the references that it cited, for 15 European countries whose guidelines cited at least 75 references. ***Countries with > 600 cited references shown by blue bars; countries with > 250 cited references shown by striped bars; and countries with < 250 references shown by light blue bars. For country ISO codes, see Table 1.***

The final tally of cited references was 5,941 papers; this total included many duplicates as some papers were cited by several different CPGs (multiple citations)– the maximum being 17 cites for two papers. The "most-cited" five are listed in Table 7, which also shows the citing and cited countries. It is notable that although there are many citing countries to these five papers, the cited countries are primarily the UK (2.26 papers) and the US (1.96 papers) on a fractional count basis. The papers that were cited on the CPGs were, as expected, mainly in the field of diabetes research. Of the articles and reviews with a EUR31 address and published in the years 2002-13, 1,121 of 1,569 (71%), were in the diabetes file. Table 6 shows that they were very well cited in the WoS compared with the average ACI for European papers in 2002-12 of 17.6 cites.

Table 6. Comparison of five-year citation scores in the Web of Science for diabetes papers cited on European Clinical Practice Guidelines with the numbers of cites on these guidelines.

Cites on diabetes CPGs	*Five-year cites (ACI) on WoS*	*N*
1	36	1274
2	67	193
3	100	58
4	196	26
5	256	8
6 to 9	376	8

12 or 17	1354	2

Table 6. Five diabetes papers with many citations (N) on European clinical practice guidelines published in 2002-13, with identification of the citing and cited countries. ***For country codes, see Table 1. Numbers in parentheses under "Citing" are the numbers of CPGs from that country; under "Cited" they are the fractional counts.***

Reference	***N***	***Citing***	***Cited***
Holman-RR Paul-SK Bethel-MA Matthews-DR Neil-HAW (2008) 10-year follow-up of intensive glucose control in type 2 diabetes. *New Engl J Med*, Vol 359, Iss 15, pp 1577-1589	17	AT, CZ, DE, ES (3), FI, HR, HU, IT, NL, PT (5), UK	UK only
Turner-RC and many others (1998) Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*, Vol 352, Iss 9131, pp 837-853	17	AT (4), BE, CZ, ES (4), FI, HU, NL, PT, RO, SE, UK	UK only
Chitwood-M and many others (1993) The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes-mellitus. *New Engl J Med*, Vol 329, Iss 14, pp 977-986	14	AT (4), BE, CZ, ES (4), FI (2), HU, RO, SE, UK	US (0.92), CA (0.08)
Patel-A and 24 others (2008) Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *New Engl J Med*, Vol 358, Iss 24, pp 2560-2572	12	AT (2), ES (2), GR NL, PT (4), SE, UK	UK (0.26), AU (0.22) and 8 others
Knowler-WC Barrett-Connor-E Fowler-SE Hamman-RF Lachin-JM Walker-EA Nathan-DM (2008) Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New Engl J Med*, Vol 346, Iss 6, pp 393-403	11	AT (3), BE, DE, ES (2), FI (2), NL, UK	US only

European newspaper stories about diabetes research

The file of newspaper stories about diabetes research contained 8,596 stories, of which 822 entries (9.6%) concerned diabetes. This shows a substantial interest by the press in the disease, as diabetes research accounted for only 5.9% of European biomedical research and only 4.3% of the disease burden measured in Disability-Adjusted Life Years (DALYs), (Begum *et al.* 2017). The stories appeared in 30 different European newspapers from 22 countries, led by *Daily Mail* (UK) with 126, *Le Soir* (Belgium) with 111 and *The Guardian* (UK) with 102. The individual journals whose papers particularly attracted the journalists' attention were high-profile general medical journals, many of them weeklies such as *The Lancet* (61 papers), *JAMA* (47) and the *New England Journal of Medicine* (45). There were 125 stories that cited papers in diabetes journals (15%): this is far fewer than the number expected from their presence in diabetes research (42%, *v.s.*). The stories were categorised by our researchers, both on the application (disease area) and the type of research (*e.g.*, drugs, genetics). Half of the stories concerned type 2 diabetes; less attention was given to type 1 (15%) and very little to the various *sequelae*, such as vascular effects (1.3%) and the effects on kidneys (1.3%) or eyes (1.1%). The stories concentrated on the causes of diabetes and how it could be prevented, rather than on methods of treatment. Thus, 22% were about the effects of diet, 19% about epidemiology, 17% about genetics and 15% about the effects of lifestyle choices. Only 10% covered treatment, mainly with drugs, and 8% discussed the provision of insulin.

Some 150 of the stories (16%) quoted the views of commentators on the significance of the results; 50 were in the *Daily Mail* (UK), 30 in *The Guardian* (UK) and 14 each in *Le Soir* (Belgium) and *Svenska Dagbladet* (Sweden). There were 130 different individuals mentioned, led by Iain Frame (15 quotes) of Diabetes UK, a collecting charity. Diabetes UK was quoted in 38 stories in total. The other main source of comments was universities, which were quoted 31 times.

As with the papers cited by CPGs, most European countries' research was relatively over-cited in the newspaper stories, see Figure 7, which can be compared with Figure 3. There is a similarity between the two charts, but the over-citation ratios for most European countries are higher for the newspaper stories, particularly those for the top four, Finland (FI), Norway (NO), the UK and Belgium (BE). Once again, Asian research is largely neglected other than that from Singapore (SG).

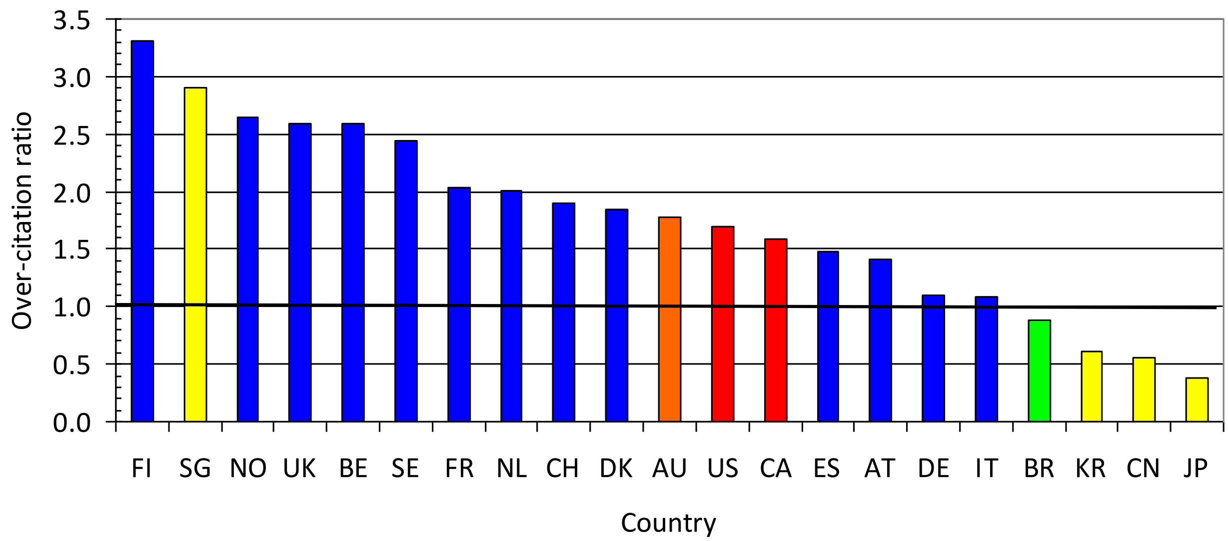

Figure 7. Over- (or under-) citation ratio for countries' papers in European newspaper stories other than from own country (limited to those with at least 15 papers cited in the stories). ***European countries blue, north American countries red; south American country green; east Asian countries yellow; Australia orange. For country ISO codes, see Table 1.***

A comparison of the over-citation ratios for own country and for papers cited by news stories from other countries is shown in Figure 8.

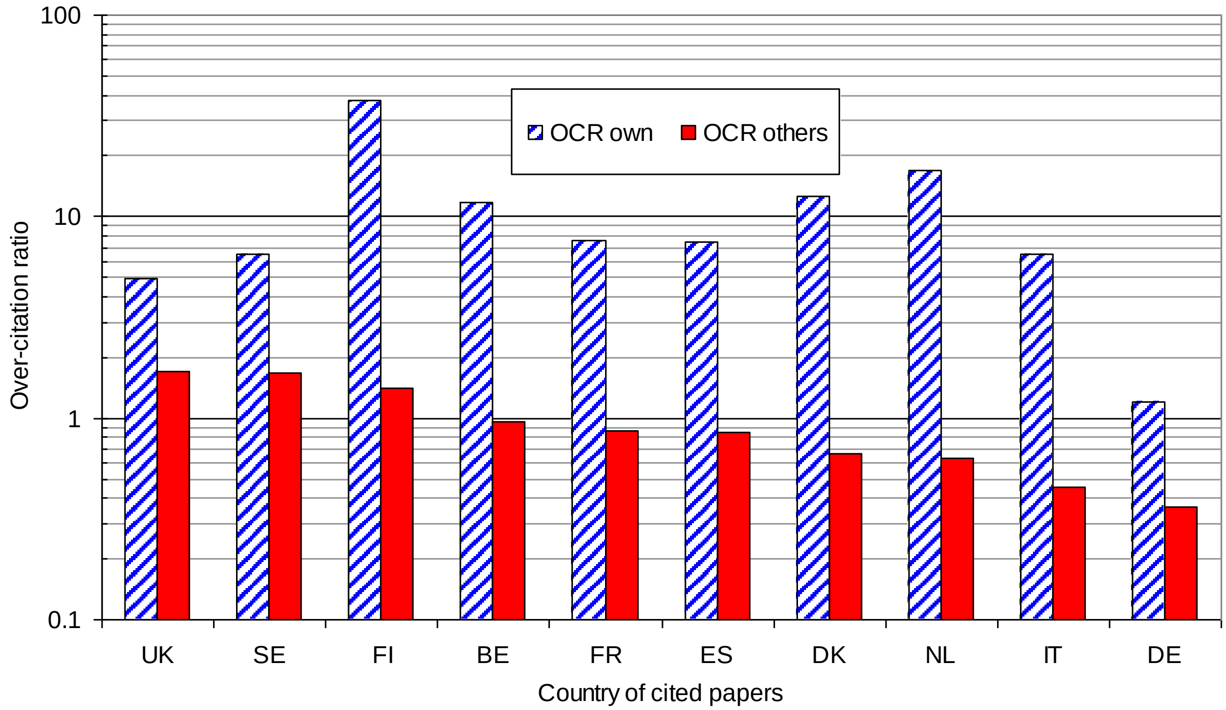

Figure 8. OCR for 10 European countries' papers cited in newspaper stories from own country (blue striped columns) and from stories from other European countries (red columns) compared with their presence in diabetes research, 2002-13, fractional counts. ***For country ISO codes, see Table 1.***

Whereas the papers cited by CPGs were much more clinical than most diabetes research papers, the ones cited in news stories were more mixed. The mean RL of the papers was 1.58 and of the journals in which they were published, 2.01. These averages are rather comparable to the values for European diabetes research (1.68 and 1.91, respectively, *v.s.*). So, the newspapers included some quite basic research among the papers that they cited, because their primary concern was prevention rather than treatment.

There were some papers that were cited in several different newspapers, though many fewer than with CPGs as we only covered 30 newspapers compared with 103 guidelines. The six top-cited papers are shown in Table 8. None of them are also in Table 7. The distribution of numbers of papers and counts of citations in newspaper stories is shown in Figure 9 which also shows the relationship for citations on CPGs. A power-law describes the relationship with high accuracy for both sets of cited papers.

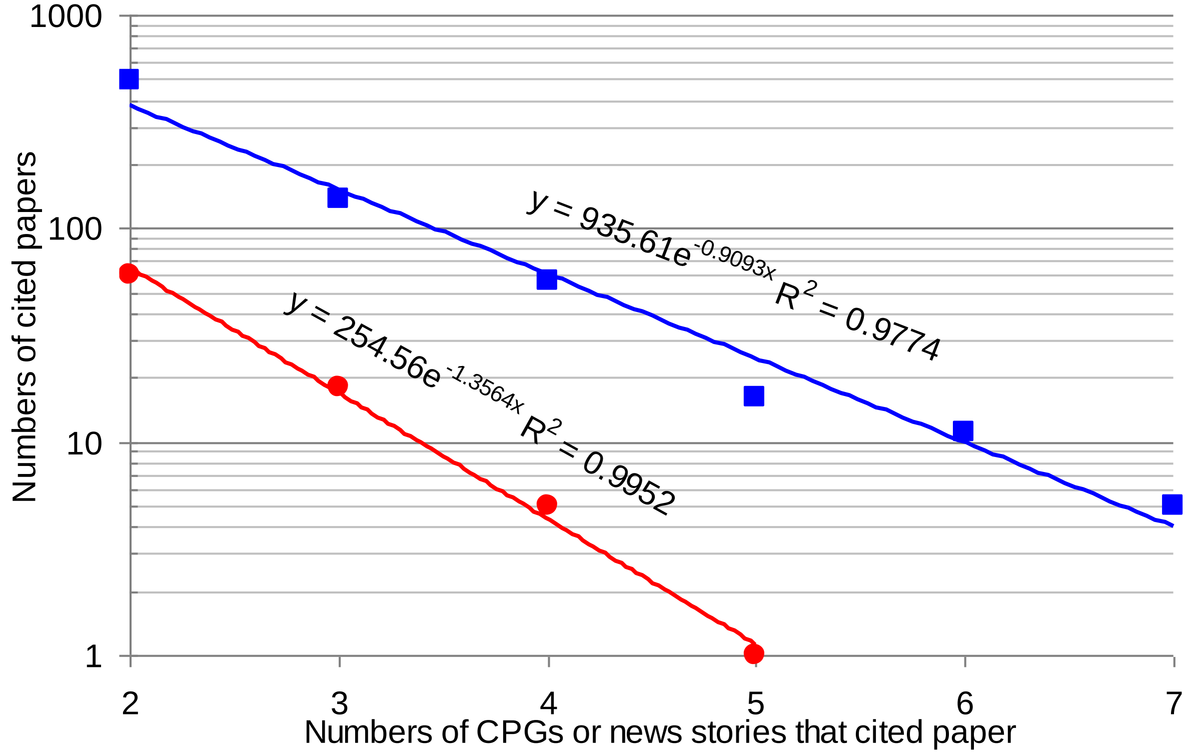

Figure 9. Relationship between numbers of papers cited by diabetes CPGs (blue) and newspaper stories (red) and the numbers of citations by these documents.

Table 7. Diabetes papers cited in five or more European newspaper stories, 2002-13. ***For country codes, see Table 1. Numbers in parentheses under "Citing" are the numbers of CPGs from that country; under "Cited" they are the fractional counts.***

Reference	***N***	***Citing***	***Cited***
Sladek-R *et al.* A genome-wide association study identifies novel risk loci for type 2 diabetes. *Nature*, 2007, Vol 445, Iss 7130, pp 881-885	7	BE (2), FR, NL, PT, UK (3)	CA (0.63), FR (0.21), UK (0.16)
Nissen-SE *et al.* Effect of rosiglitazone on the risk of myocardial infarction and death from cardiovascular causes. *New England Journal of Medicine*, 2007, Vol 356, Iss 24, pp 2457-2471	6	DE, DK, FI, NL, UK (2)	US only
Burton-PR *et al.* Genome-wide association study of 14,000 cases of seven common diseases and 3,000 shared controls. *Nature*, 2007, Vol 447, Iss 7145, pp 661-678	5	ES, FR, RO, UK (2)	AU (0.02), FR (0.02), GM (0.02), UK (0.94)
Huxley-R *et al.* Coffee, Decaffeinated Coffee, and Tea Consumption in Relation to Incident Type 2 Diabetes Mellitus A Systematic Review With Meta-analysis. *Archives of Internal Medicine*, 2009, Vol 169, Iss 22, pp 2053-2063	5	CZ, GR, NL (2), PL	AU (0.2), FR (0.2), NL (0.2), UK (0.2), US (0.2)
Micha-R *et al.* Red and Processed Meat Consumption and Risk of Incident Coronary Heart Disease, Stroke, and Diabetes Mellitus A Systematic Review and Meta-Analysis. *Circulation*, 2010, Vol 121, Iss 21, pp 2271-U52	5	BE (2), DK, HR, UK	US only
Tasali-E *et al.* Slow-wave sleep and the risk of type 2 diabetes in humans. *Proceedings of the National Academy of Sciences of the United States of America*, 2008, Vol 105, Iss 3, pp 1044-1049	5	BE, DE, UK (3)	US only

Obesity was the single most studied subject, with 110 papers (11%) including this word (together with *obese* and *overweight*) in their titles. Next came *coffee* with 34, *exercise/physical activity* with 25, and *sleep* with 24. All are concerned with prevention.

We have generated seven different criteria for the relative evaluation of European countries' research in diabetes, and Table 9 shows that no country dominates, although some are clearly scoring more highly than others. Four countries have a position in five of the seven orders of merit: Denmark (DK), Finland (FI), Switzerland (CH) and the UK, and Sweden (SE) is in four of them. This diversity of rankings suggests that it would be misleading to use just a single indicator of merit, and that different countries show to advantage on different measures (Martin, 1996).

Table 8. Ranking order of the European countries in diabetes research, 2002-13, on seven different criteria: Arith=arithmetic citation mean, Geom=geometric citation mean, 5%=presence in top cited 5% of papers, OCR=over-citation ratio for own papers, compared with that for WS citations; Revs=percentage of reviews, CPGs=over-citation ratio for CPGs from other countries, NSs=over-citation ratio for newspaper stories from other countries. ***For country ISO codes, see Table 1.***

	Citations in the serial literature				*Reviews*	*CPGs*	*NSs*
Rank	*Arith*	*Geom*	*5%*	*OCR*	*%*	*OCR*	*OCR*
1	IS	FI	FI	FR	UK	UK	UK
2	FI	DK	CH	DK	GR	DK	SE
3	DK	NL	BE	CH	BG	FI	FI
4	BE	CH	IS	NL	PT	SE	BE
5	CH	NO	UK	SE	FR	NL	FR
6	UK	SE	DK	DE	CH	IT	ES

Although the last two columns record the practical effects of the diabetes research from different countries, there is some bias because we were unable to examine the CPGs and newspapers from all European countries, and the rankings to some extent reflect the national origins of these two types of document. For example, the newspaper stories were dominated by results from two UK newspapers (*Daily Mail* and *The Guardian*) which contained far more medical stories than most continental European newspapers. However, this dominance would not have affected the high ranking of the UK in other newspapers except that some papers took a few of their stories from those originally published in British newspapers.

Discussion

The number of CPGs available to diabetes practitioners has increased over the years. Papers cited in the guidelines tend to be more clinical in nature than the average for the journals in which they were published. This suggests a greater coherence and a focus on agreed models of care. Guidelines seem to be up-to-date, referencing relatively recent publications (the inter-quartile range of publication dates was between 2000 and 2008). However, there is heterogeneity across countries in terms of the delay in the uptake of most recent evidence in the guidelines, with some countries citing references a decade old on average. This could suggest the need to revise the updating process of some of the guidelines in order to facilitate incorporation of the most recent findings in the literature in the guidance for clinical practice. Additionally, the OCR (Figure 4) may reflect an information bias with respect to the citation of diabetes research from own country within the CPGs. This is particularly important in an era of evidence-based practices and such evaluation of the research evidence origin may in fact indicate factors related to the management of the disease in a particular country or healthcare system like Sweden or the other Scandinavian countries (Figure 3). However, the extent of this influence in clinical practice can perhaps be investigated further in a future study. Future evaluation of available CPGs for diabetes according to criteria of pragmatism and conciseness (Jackson and Feder 1998) should be conducted.

The analysis of dissemination trends for research results through newspaper stories is particularly relevant to define effective strategies to raise awareness of diabetes among the general public and promote evidence-based discourse. The presence of external commentators will help to give confidence and credibility in the advice being given, particularly if they are from well-respected sources such as academia and collecting charities. The majority of stories concerned type 2 diabetes, with less attention given to other types of diabetes and the effects of the disease. Most stories concentrated on causes and prevention, rather than treatment. While this analysis offers a general overview of subject areas and the focus of newspaper stories, further studies could build on existing literature on diabetes in the news media (Gollust and Lantz 2009; Hellyer and Haddock-Fraser 2010; Rock 2005) to conduct a detailed content analysis of the stories found.

Some limitations have to be taken into consideration in the interpretation of the study results. First, evidence suggests that health-related articles in social sciences in languages other than English tend to be under-recorded (Nederhof 2006), and under-represented in the bibliographic databases (Van Leeuwen *et al.* 2001). A certain degree of publication bias related to language should therefore be taken into account. Second, the research articles found were not individually evaluated for quality. This is a general limitation of bibliometric research (Similowski and Derenne 1994). Moreover, differences in national contexts limit the value of a one-size-fits-all bibliometric method for research evaluation: methods tailored to different contexts may provide more reliable results (Haustein and Larivière 2015).

Nevertheless, the results provide a novel insight into the evaluation of European countries' performance and the impact of different subject areas of diabetes research, both through the dissemination of study findings in the academic serial literature, and through their use in clinical practice and information to the general public through the mass media.

Conclusions

This paper was intended to show three different sources of indicators using citation data, namely the serial literature as recorded in the WoS, references on clinical practice guidelines, and stories in newspapers. Each can provide valid measures of the impact and utility of medical research publications, and countries may perform differently on the individual indicators. So, there were three different measures of citation performance for the EUR31 countries, and their rankings differed. None of them can be regarded as the most important: multiple indicators are just better than one (Martin, 1996). The comparisons are between countries, and to lesser extent subject areas, within diabetes. The increased emphasis nowadays being placed on demonstration of the social and economic impacts (Di Cagno, Fabrizi & Meliciani, 2014; Habets, van Delden & Bredenoord, 2014; Chowdhury, Koya & Philipson, 2016; Prettner & Werner, 2016; Solarin & Yen, 2016) stemming from research make the described methodologies herein of particular value to future evaluations of medical research.

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